FINER POINTS

"The ONLY magazine dedicated solely to the technology and application of superabrasives."

INTERTECH 2008 Review

SUMMER 2008

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INTERTECH 2008 Paper Excerpts

IDA Membership Application

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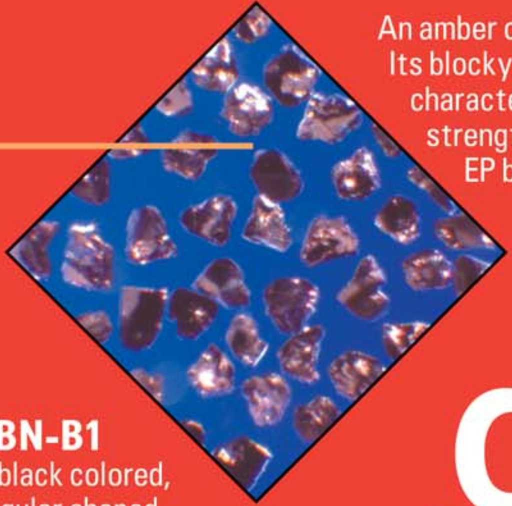

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COVER PHOTO

Photo courtesy of Boeing Company.
Picture shows the Boeing assembly line for 777 Jetliner.

FINER POINTS is the only publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these "superabrasives", either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

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A Finer Point of View…

Human beings are tools of knowledge. Every one of us wants to learn more and sharpen our intellect. We should constantly be taking advantage of our freedom to learn, to saturate our minds with matter that encourages our usefulness. It is the responsibility of those with knowledge to share their life experiences and information with others. This cycle of shared knowledge promotes advancements, cures diseases, invents comfort, and provides relief. We are dependent on knowledge to survive, and the source of intellectual growth is education. The chain of education is lengthy, one that unravels quickly without constant communication and widespread participation. In both the scholastic and professional arenas, the lack of support for education is a guarantee of failure in the future. The Industrial Diamond Association is developing an educational platform from which its members can learn more about the diamond industry and apply this knowledge to their professional responsibilities. This educational platform will provide a renewed understanding of equipment, applications, products and value. Superabrasive Certificate Courses are meant to promote the cycle of informing, sharing and applying while derailing the forces of "me too" and low-value commoditization. No individual can surmount this hurdle, but the power of an association can halt and reverse this trend. Superabrasive manufacturers and distributors have fallen victim to these forces; all the while their product is one of the most reliable and effective materials in the world. If ever there was a product that exclaims its features and benefits outright, it is superabrasives. In order to end this cycle that undervalues our products, the industry must depend on seeking education and sharing knowledge. A lucid understanding of the value of superabrasives and their functions in the industry must be appreciated by each person involved: sales person, purchasing manager, engineer, operator, end user, and owner. An organized and motivated association can seek out sound information regarding superabrasives and communicate this knowledge to all parties benefiting from the industry. The superior capability of superabrasives depends on our knowledge, not legal tender, not quantity, not hand shakes. Your participation in the upcoming Superabrasive Certificate Course is paramount in appreciating the benefits, features and uses of superabrasives. Contributions to the courses through white papers, speaking engagements, field study reports, employee attendance or event hosting are encouraged, and attendance is a guarantee of intellectual proliferation that is meant to be shared with and applied in your professional domain. The successes of superabrasives are seeded in education, and it is our responsibility to promote their value and help to grow a healthy industry for all segments of the value chain. Strive to educate yourself and contribute to the learning of others on a daily basis, whether that knowledge concerns diamonds or dragons. Knowledge is power.

PRESIDENT
Martin Deakins

Sincerely,

Martin Deakins

Martin Deakins, President
Industrial Diamond Association of America

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FINER POINTS is the official publication of the Industrial Diamond Association of America, Inc. and is published fours times a year. Contributions are welcomed but the Editor reserves the right to accept or reject any material for publication. All by-lined articles published in this magazine represent solely the individual opinions of the writers and not necessarily those of the Industrial Diamond Association. Executive and Editorial Offices: Finer Points, P.O. Box 29460, Columbus, Ohio 43229, (614) 797-2265. Editor and Advertising, Terry Kane. Advertising rates and deadlines available upon request.

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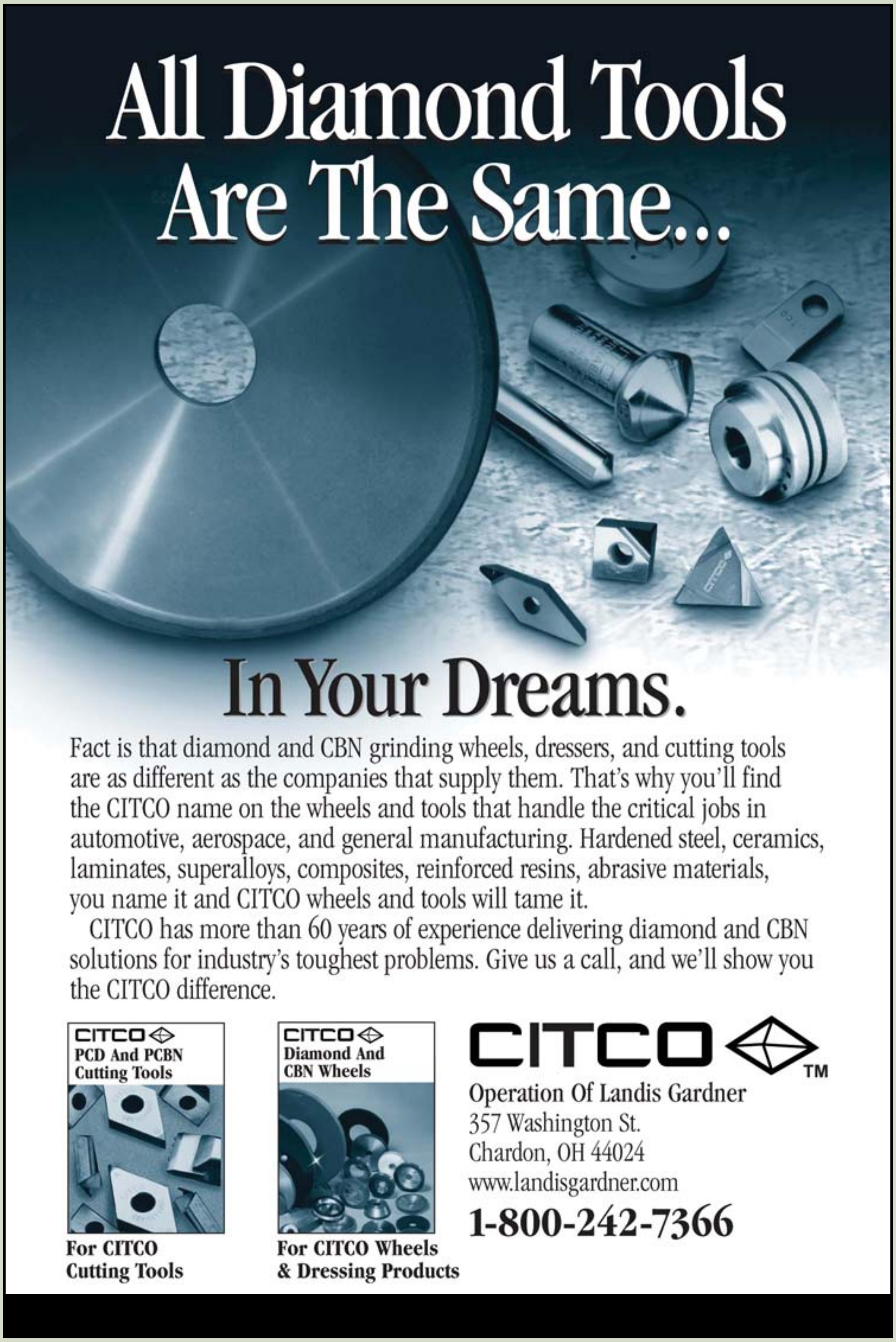
Editorial

TERRY KANE, Editor

A Rising Tide Raises All Ships

When sales and use of superabrasives improve it helps all companies in the industry. Our recent INTERTECH 2008 held this past May was another success and as such was a success for the entire industry. Every two years the brightest and most innovative scientists, engineers and industry leaders grace the stages of INTERTECH to present their finest offerings of new products, new applications and advancements in technology. It was here we first heard of many the products that today are the mainstays in production lines for automotive and aerospace. We also learn of basic crystal improvements and coatings that are helping to change the face of construction applications, stone processing and the ever-important highway, dam and bridge renovations and restoration. From the far reaches of space in satellites and shuttles, to the depths of the ocean in communication and exploration, diamond and other "superabrasives" continue to touch every part of our lives. I continue to be amazed every time I sit in one of the presentations and listen to what is new or what has been rethought for a new approach to an established process or product. What may have been forgotten or shelved five or ten years ago is now reintroduced and finding success in another way. Forums like INTERTECH in the Americas, Diamond At Work in Europe and the 5th ZISC in Asia showcase the global research and applications for our industry. Through these well-staged and professionally executed conferences, attendees learn and share. These conferences are a way to promote the use of superabrasive materials and give attendees an insightful view of what may be the next generation abrasive or application. One of my favorite terms is "cross-over technology" referring to applications or use in one industry that can be adapted to another industry. We see this in the use of superalloys, metal matrix composites, bi-metals and other materials used in aerospace that are now making great inroads in automotive. Drilling products, once only used on bits for oil and gas exploration are being used on chainsaws for stone and concrete. Cubic boron nitride, a material that was supposed to only be applied on ferrous materials is being electro-plated and used as a milling tool for aluminum! CVD diamond is applied in woodworking and in intricate wear part configurations and saw diamond is finding success in wire sawing steel pipes beneath the ocean. Maybe most importantly, the medical field is using diamond in everything from optics to prosthetics and joint replacements… a true reflection of improving the quality of life. The limitations of yesterday are being brushed aside and new applications are finding success from one industry to the next. As these new products and applications are shared at the major conferences, others are taking those ideas and expanding them around the world in ever increasing and creative ways. As the use of superabrasives grows and more people are educated and become aware of the possibilities, all companies involved in their use share in this success … ***a rising tide raises all ships!***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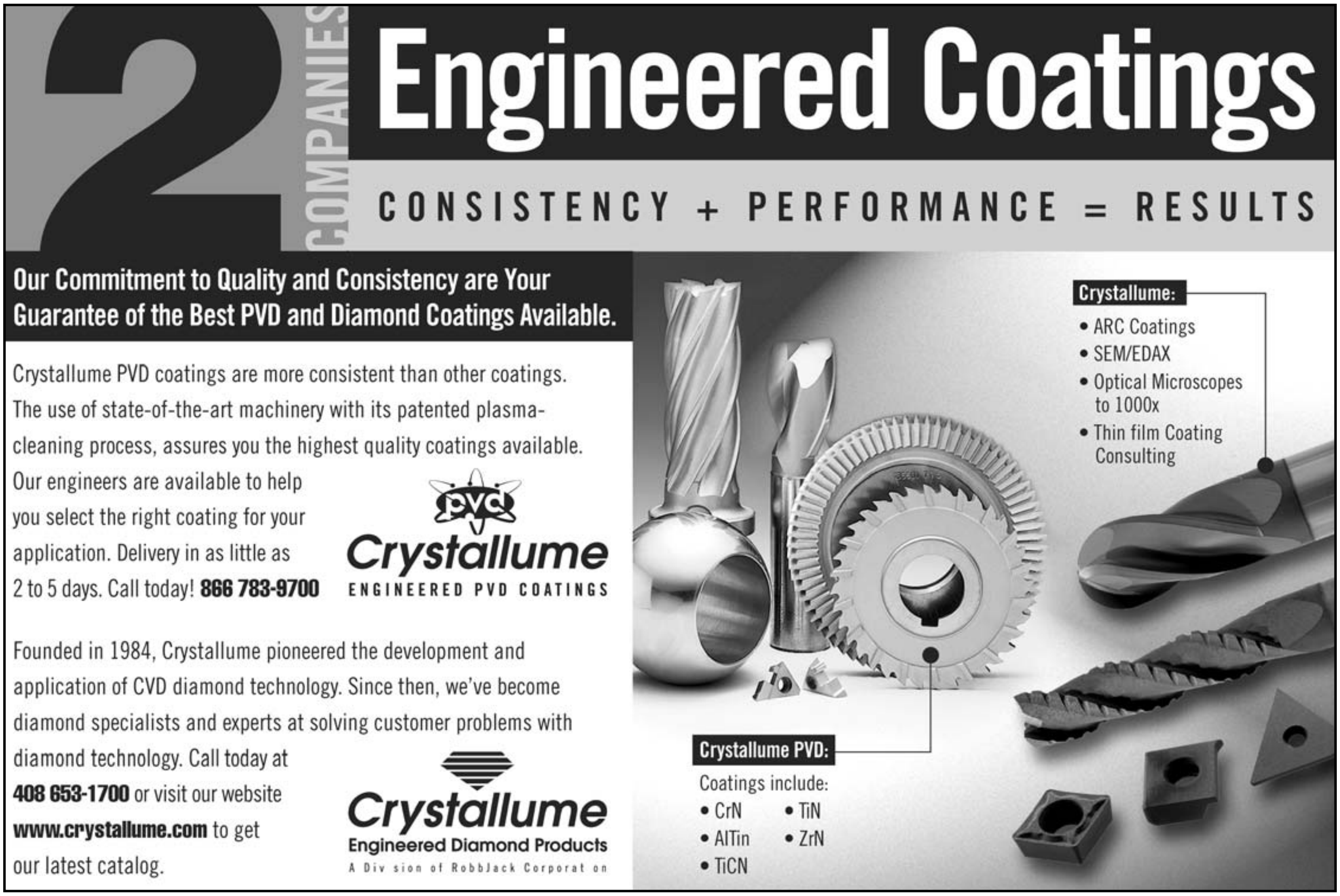
IDA Annual Meeting Summary

The 62nd Industrial Diamond Association was a memorable event. A new Board of Directors and Officers were installed: Mr. Martin Deakins of Diamond Innovations as President, Dr. Ion Benea as Vice President and Mr. David Edwards of Action Superabrasives as Secretary/Treasurer. The 2008 Board of Directors is made up of: Mr. William Herbst of Advanced Superabrasives, Mr. Mike Mustin of American Superabrasives, Mr. Edward Galen of Cinetic Landis Corp - CITCO Products, Mr. William Tully of Diamond Abrasives Corporation, Mr. Joseph Tabeling of Delaware Diamond Knives, Mr. Jay Lunzer of Lunzer Inc. and Mr. R. Christian Winkel of Worldwide Superabrasives. The general membership welcomed this dedicated group of Officers and Directors and expressed their appreciation that this group has accepted the role of leading the Association. In addition to reviewing the general business activities of the Association and setting goals and objectives, the IDA Members were given excellent presentations on the economy with an analysis by Adam York an Economist for Wachovia Bank plus had an interactive discussion with Kelly Phou, Chief, Collections Coordination Branch, Foreign Trade Division for the US Census Bureau on compliance issues and concerns with conflict diamonds. Long time industry colleague Norm Rohr introduced a project he will be working on this year to trace the “Industry Family Tree” that will identify companies that have made the diamond industry what it is today and pinpoint where they have gone or where they are now. The Annual Meeting was capped off by a splendid banquet where all the members and guests joined in an excellent evening of social gathering and conversation. At the Banquet, Bill Tully was given the Presidents Award for exceptional service and contribution to the Association and E. Louis Kapernaros was given an Honorary Lifetime Membership in the IDA. Lou was the General Manager of GE Specialty Materials Department in the early years when “Man-Made” diamond first made its mark on the manufacturing scene. Lou directed “SMD” when many of the first in “superhard” materials were invented and introduced including Cubic Boron Nitride, Polycrystalline Diamond, Polycrystalline CBN, drill diamond, polycrystalline wire dies, crystal coatings and many other innovative and revolutionary materials. Lou was credited with being a catalyst in the major growth of these materials throughout the world. Tanya Fratto, current CEO & President of Diamond Innovations, the company that is the descendent of SMD presented the award on behalf of the IDA and reflected on her conversations with former colleagues of Mr. Kapernaros and how they respected and held him in high regard. Lou’s Lifetime Membership Award read in part: “For distinguished service and leadership in the research, market development and sales of superabrasives resulting in the global success and growth of the entire diamond industry.” With the 2008 Annual Meeting and banquet being held on the eve of INTERTECH 2008 many of Lou’s former employees, colleagues and other dignitaries from the industry were present to honor Lou and take part in the festivities.



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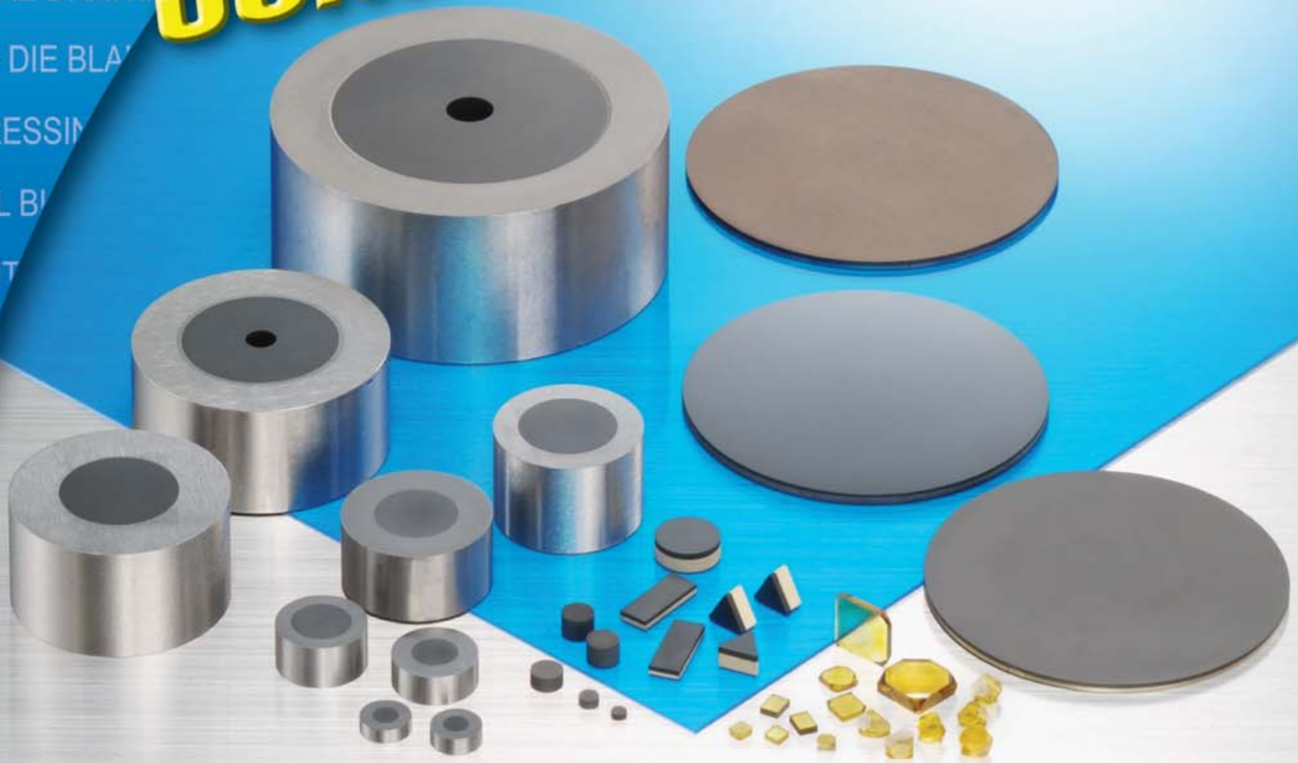

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INTERTECH 2008 Review

INTERTECH 2008, the fourth offering in the continuing series of international conferences on diamond, cubic boron nitride and their applications was hailed as a tremendous success by all attendees. The conference held May 5-7 at Disney's Contemporary Resort, once again hosted global business leaders from major suppliers, tool manufacturers and end users. Over 200 attendees were treated to outstanding presentations from leading international companies and research facilities on topics ranging from CVD development and drilling advancements to grinding innovations and saw diamond applications. There were 60 papers and presentations selected from almost 100 submissions and abstracts for delivery at **INTERTECH 2008**. Portions of a few papers are shown in the following pages and the entire proceedings can be ordered online at www.intertechconference.com. One of the attractions of **INTERTECH 2008** were the tabletop exhibits where suppliers and support companies to the industry showed their products and spent time holding impromptu meetings with attendees. A major highlight of **INTERTECH 2008** were the keynote addresses given by featured speakers:

- WILLIAM J. WALKER, Jr., Ph.D., Manager - Ceramic Research Engineering Ignition Products Group Federal-Mogul Corporation spoke on Ceramic research and applications in the automotive industry.
- JEFFREY E. POST, Ph.D., Curator National Gem and Mineral Collection Smithsonian Institution covered areas of research including mineralogy, gemology, geochemistry, crystallography, and electron microscopy on gems and materials at the Smithsonian.
- JAMES D. CAMPBELL, CSMC Machining Discipline Chief Pratt & Whitney gave the attendees an interesting behind the scenes look at applications in Aerospace as well as new materials being developed.
- JEFFERY K. TAYLOR, MD Chief Science and Technology Officer Dimicron, Inc. spoke on the fascinating developments and applications of diamond in prosthetics and joint replacement.
- TAKERU NAKASHIMA, Superabrasives Manufacturing Engineering Manager Sumitomo Electric Hardmetal Corp. gave an interesting and informative overview of the Asian Superabrasive Market and statistics related to how the Asian market compares to the rest of the world
- MARK SCHWEIZER, Vice President, Global Product Management and Marketing Diamond Innovations explored the superabrasive tool value chain – from superabrasive manufacture to toolmaker to end-user – and the reason for different business models. His discussion showed the opportunity for improved value creation by focusing on life cycle economic and productivity improvements.

INTERTECH continued it's global reach with participants from 19 countries. The breakdown by percentage showed 50% from the Americas, 30% from the Pacific and 20% from Europe. Initial reviews showed attendees were overwhelmingly positive about all aspects of **INTERTECH 2008** including the quality of the program, special events, papers, venue and dining. Many comments stated attendees are looking forward to the next INTERTECH in 2010 at the Lake Las Vegas resort in Henderson, Nevada!

Announcements & PRODUCTS

GATEWAY SAFETY'S SOUND SERIES™ EARMUFFS: INDEPENDENTLY TESTED FOR PROVEN PROTECTION LEVELS

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PINPOINT LASER SYSTEMS® IS INTRODUCING A REVOLUTIONARY NEW 2 DIMENSIONAL MICROGAGE

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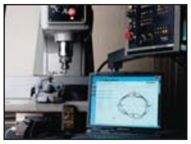
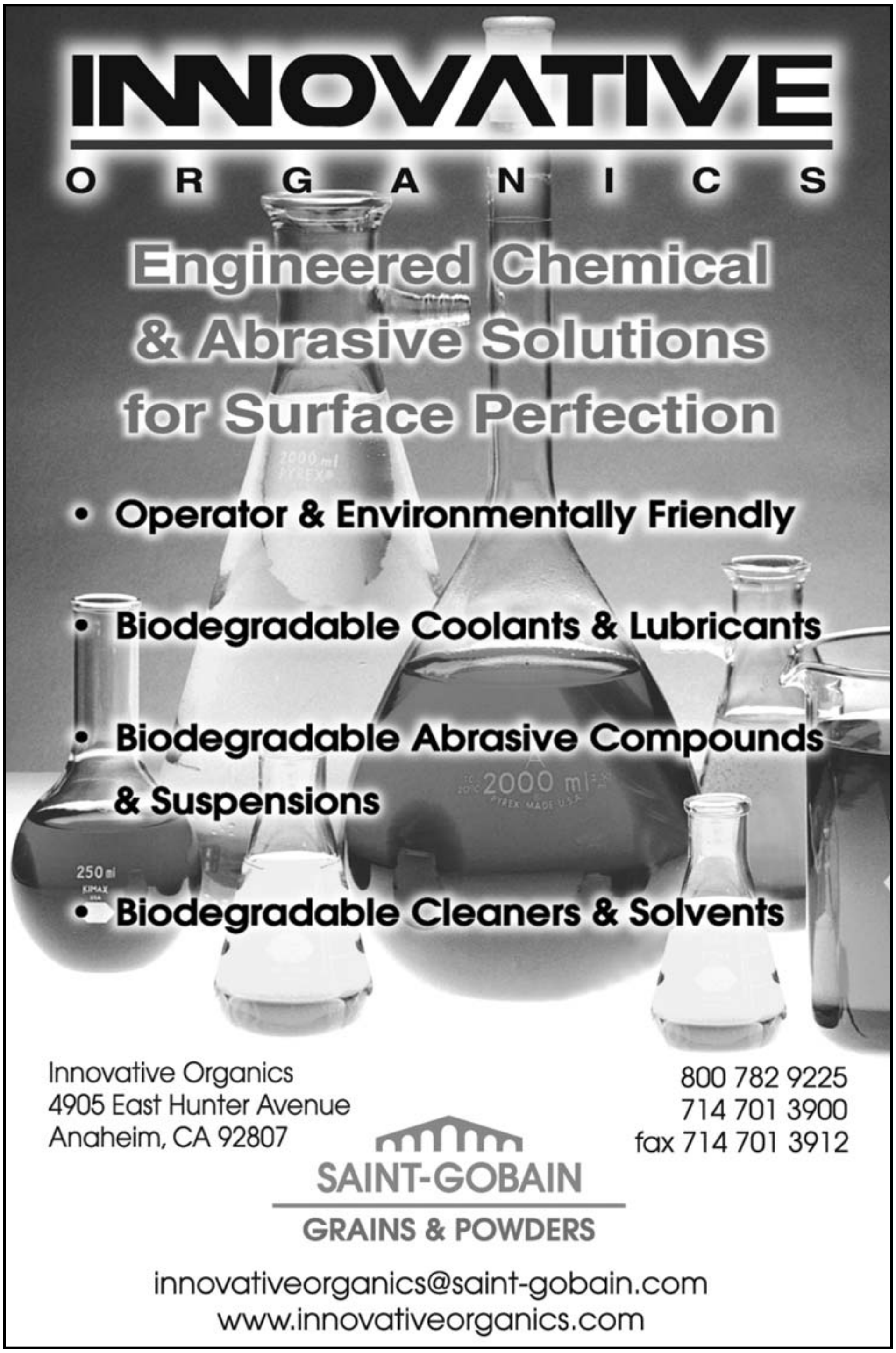


RENISHAW QC10 BALLBAR ESTABLISHED

June 2008 – The Renishaw QC10 ballbar has established itself as a system for quick machine tool and motion system analysis and diagnosis. An easy set-up and test procedure (often less than 10 minutes per machine) and comprehensive reporting/ analysis software make the system the most powerful and flexible diagnostic tool available. The highly portable QC10 ballbar automatically detects and diagnoses a range of machine geometry, and motion errors. Clearly visible plot trends allow maintenance requirements to be scheduled in advance and plot discontinuities help fault diagnosis after a machine crash. **Visit Renishaw's web site at: www.renishaw.com**

MEISTER ABRASIVES UNVEILS NEW HYBRID DIAMOND DRESSING TECHNOLOGY

North Kingstown, RI – Meister Abrasives has introduced a remarkable new hybrid bonding technology for rotary diamond products used to dress CBN grinding wheels. The company's new hDD (hybrid diamond dressing) tools combine the toughness of metal bonding with the natural porosity of a vitrified bond structure, comparable to porosity found in vitrified CBN grinding wheels. The many advantages of this new combination include more efficient dressing cycles that lead to more consistent CBN grinding wheel performance, increased intervals between dresses resulting in longer grinding wheel life, improved longevity of the dressing tool itself, and total elimination of the need to change out the dressing tool for re-conditioning. One of the secrets of this new technology is a proprietary manufacturing process that both mechanically and chemically bonds the diamond particles within the tool to insure that they will be held securely. As a result, metal posts or "bridges" that attach to the diamond crystals in the bonding matrix can be slender, allowing for large pores to be naturally distributed between the crystals. The improved porosity means that hDD rotary dressing tools are freer cutting, carrying more material and heat away from the CBN wheel with every revolution. This creates a better surface condition on the CBN wheel and does it faster. More efficient dressing means that CBN grinding wheels last longer, because less superabrasive needs to be removed, less often, to return the wheel to optimal condition. **For information, contact: Bruce Northrup, brucenorthrup@meister-abrasives-usa.com**



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Calendar of EVENTS

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MiNiN2008
III International Conference on Mining Innovation

August 6-8, 2008
INTERNATIONAL CONFERENCE ON MINING INNOVATION
Sheraton Hotel & Convention Center
Santiago, Chile
www.minin2008.com

5th ZISC Zhengzhou International Superhard Materials and Related Products Conference

September 5-7, 2008 5th ZISC
Songshan Hotel, Zhengzhou China
http://www.idacn.org/huiyizhuanlan/hotel.php

DIAMOND 2008

September 7-11, 2008
Sitges, Spain
www.diamond-conference.elsevier.com

IMTS08 CONNECTING GLOBAL TECHNOLOGY

September 8-13 IMTS 2008
International Manufacturing Technology Show • McCormick Place
Chicago, IL USA • www.imts.com

September 23-26 WIRE China 2008
The 3rd All China-International Wire & Cable
Shanghai New International Expo Center
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http://www.wirechina.net

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February 3-6, 2009
Las Vegas Convention Center
Las Vegas, NV USA
www.worldofconcrete.com

MARCH 9-11, 2009
Industrial Diamond Association of America
Annual Meeting
The Colony
Long Boat Key, Florida USA
www.superabrasives.org

3rd International Industrial Diamond Conference
16-17th April 2009 Paris France

April 16-17, 2009
3rd Diamond at Work
Etoile Meridien Hotel • Paris, France
www.diamondatwork.com

INTERWIRE TRADE EXPOSITION • IFE

April 25-30, 2009 Interwire 2009
I-X Center • Cleveland, Ohio, USA
www.wirenet.org

OTC 09 2009 Offshore Technology Conference
4-7 May :: Reliant Park :: Houston, Texas, USA

May 4-7, 2009
Offshore Technology Conference
Houston, TX USA • www.otcnet.org/2009

CALENDAR EVENTS for 2010

MARCH 13-14, 2010
Industrial Diamond Association of America
Annual Meeting
The Ritz Carlton Lake Las Vegas • Henderson, NV USA
www.superabrasives.org

INTERTECH 2010
An International Technical Conference on Diamond, Cubic Boron Nitride and their applications.
www.intertechconference.com
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March 15-17, 2010

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China Abrasives Import & Export Corporation (CAEC), established in 1981, is the vice Chairman of Industrial Diamond Association of China. CAEC is IO9001:2000 Quality System controlled and our Chief Engineer has 40 years working experience in Superhard Abrasives Industry. With 27 years experience and advanced testing devices our products are controlled strictly in Quality Consistence.

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5. Polycrystalline diamond composite (PDC)
6. PCD/PCBN cutting tools
7. Diamond saw blades
8. Diamond electroplated products
9. Related machines

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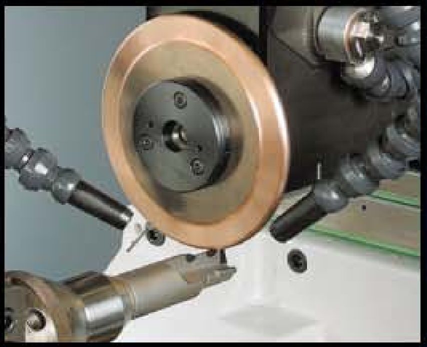

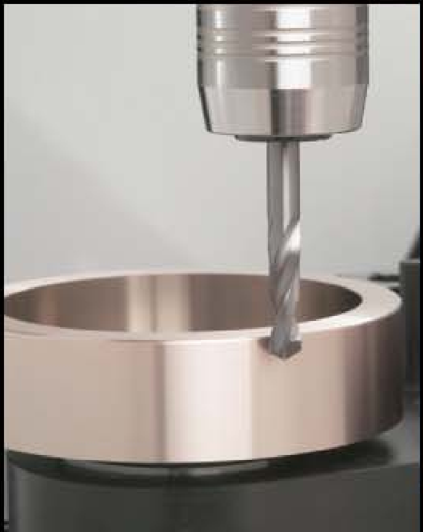

Paper Excerpts of INTERTECH 2008 on the following pages.

PCD/PCBN Materials – processing, applications and advantages.

SCOTT RIES, PCD Division Manager – Vollmer of America

PCD Basics

Polycrystalline diamond as we know it today, had its commercial origin over 30 years ago, and yet there still remains a great deal of questions on how to optimize its use. When PCD is discussed, it generally includes PCBN as well as PCD. PCD, in its truest sense is a carbon based element and does not work as well in machining of ferrous based materials. PCBN, or cubic born nitride is better suited for the ferrous materials due to its non carbon structure. The use of cutting tools fabricated from these superabrasive materials have helped create tremendous advances in the technology of alloys and composites used in the aerospace, automotive and many other industries. When used properly they provide increased productivity, tighter tolerances and reduced operating costs.

PCD Processing from Blanks

PCD and PCBN blanks produced today have improved greatly since their introduction in the 1970s. The first PCD and PCBN blanks designated for cutting into tipped tools were finished to 13.1mm, which is slightly smaller than a dime. At that time, there was only one grade of PCBN. PCBN designated for use as inserts were finished to a diameter of 19mm so that a BSNU43 could be produced by grinding the edges flat. This early PCD and PCBN also posed several other problems. Although the PCD was conductive, the wire edm machines were not capable of creating the intricate designs that we rely on today. Programming was done by hand and entered into the machines keyboard. Computer storage was limited in most models and many machines ran off of programs that used G/M codes created by punching holes into paper and Mylar tapes that were fed into the machines "tape reader". The machines were also not capable of creating cutting edges that could be used in finished applications as early power supplies were DC voltage and utilized capacitors instead of the square wave generators in use today, creating a very rough surface. These machines were also limited to 2 axis movement. Cutting speed on these early machines was 1.0 – 1.5 inches per hour for a 3.2mm thick piece. As a result, the vast majority of cut pieces were simply segments or pie shapes later brazed on to tool bodies and ground for use in metalworking, primarily turning applications. PCBN on the other hand could not be cut on the wire edm machines. Segments were created by cutting through the abrasive layer with a laser. Keep in mind that the lasers in the 70s and 80s were nothing like lasers of today either. The kerf and area damaged by the laser beam was close to 0.8mm and the lasers were only powerful enough to penetrate a little over 1mm in depth. After the laser cut the PCBN, the blanks were taken to a grinder, where a diamond dicing wheel was used to cut through the carbide layer. Parts were then snapped apart for shipment to tool makers. Today we have blanks routinely available greater than 58mm in diameter, in several different feeds in PCD, with many more compositions available in PCBN. Product technology has grown tremendously, and the machines used to create the tools have improved greatly as well. The generators on the wire and sinker edms of today use AC voltage and produce finishes that work very well in most final applications, they routinely cut at speeds greater than 11.0 inches per hour for a 3.2mm thick part. The design software using different Cad and 3D imaging make intricate geometries simple to create and load via DXF files into these machines. Many machine builders offer 4, 5 and even 6 axis control on their machines which enables the designers of today to not only control basic geometries, but also specify and create detailed edge preparations and relief angles on the finished tools. All of these improvements help optimize the final machining results for the end user.

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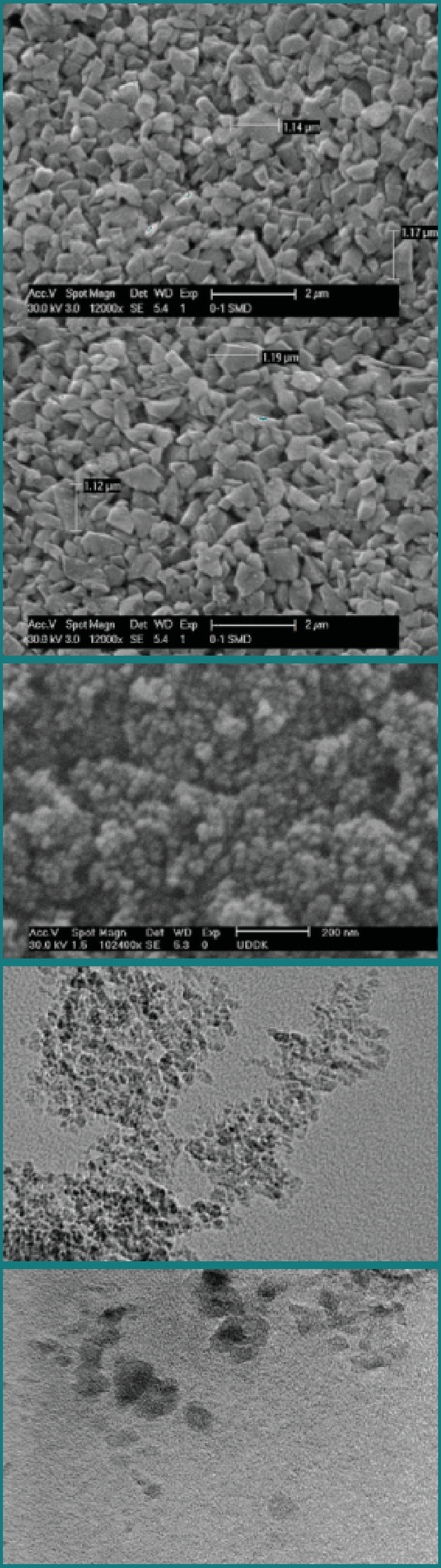
CONCLUSION

Although these products have been available since the mid 1970's, we continue to discover new and exciting applications for their use. The new applications continue to provide new sources of revenue for the tool manufacturer. Constantly improving machine technology allows for increasingly complex tool designs and improved finishing techniques. When used properly PCD and PCBN tools continue to provide increased performance, while greatly reducing operating costs for the end user.

A Comparison of the Most Popular Particle Size Measuring Principles for Diamond Percent

Nicholas J. Tumavitch, PhD, Warren/Amplex Superabrasives


1.14 µm
1.17 µm
Acc.V Spot Magn Det WD Exp 2 µm
30.0 kV 3.0 12000x SE 5.4 1 0-1 SMD
1.19 µm
1.12 µm
Acc.V Spot Magn Det WD Exp 2 µm
30.0 kV 3.0 12000x SE 5.4 1 0-1 SMD
Acc.V Spot Magn Det WD Exp 200 nm
30.0 kV 1.5 102400x SE 5.3 0 UDDK

DOPPLER SCATTERING

The Doppler light scattering technique has a particle range between 3-6000nm. The instrument measures the entire particle distribution simultaneously in about two minutes. The sample contained within the cell is stagnant from the bulk perspective. However, the particles are in a constant state of flux due to Brownian motion. This motion changes the frequency of the incoming laser. The frequency change is processed by a Fast Fourier transform into a power-frequency spectrum. The spectrum of the unknown particles is compared to the power spectrum of known particle sizes to generate the distribution of the unknown sample.

LASER SCATTERING PARTICLE SIZE DISTRIBUTION

Particle light scattering can be classified in three categories:

- Light reflecting at the outer surface of the particle nearest to light.
- Light reflecting at the inner surface of the particle farthest from light and back through the particle.
- Light refracted within the particle.

The relationship between light scattering and particle size can be explained by the Mie scattering theory, but practical application requires approximations. The approximation is basically a split in the treatment of the diffracted light. If the particle size is less than the laser wavelength, the scattering is considered Rayleigh type. If the particle is larger than the wavelength of light, the scattering is considered Fraunhofer type. Fraunhofer scattering is the easiest component to treat. For large particles, light scatters primarily in the forward direction. The relationship between particle size and light intensity is 1:1. For smaller particles, the scattered light intensifies in the rear, and finally spreads in all directions for sizes less than 100nm. Front scattering becomes constant. The schematic of a light scattering analysis uses a laser at 632.8nm and a Fourier lens to image large particles. For smaller particles, many detectors are required to capture the wide angle and back scattered light. A tungsten lamp at 405nm is also used in combination with the laser to calculate the entire distribution.

DISC CENTRIFUGE

In the disc centrifuge technique, a small amount of particles in suspension is injected onto the surface of the fluid inside of a spinning disc. The spin fluid is typically an aqueous density gradient with a small amount of low vapor pressure liquid on top to prevent evaporation. The density gradient is necessary to give all particles an equal starting line. Larger particles race through the gradient faster than the smaller ones. The disc centrifuge analyzer is unique in the sense that the laser is not measuring the scattering of all particles simultaneously, but looking at each individual bin of similar sized particles. The time required for the particle to reach the detector position is related to the diameter using Stokes' Law. The extinction of the laser by the particles is used to determine the distribution. The extinction efficiency,

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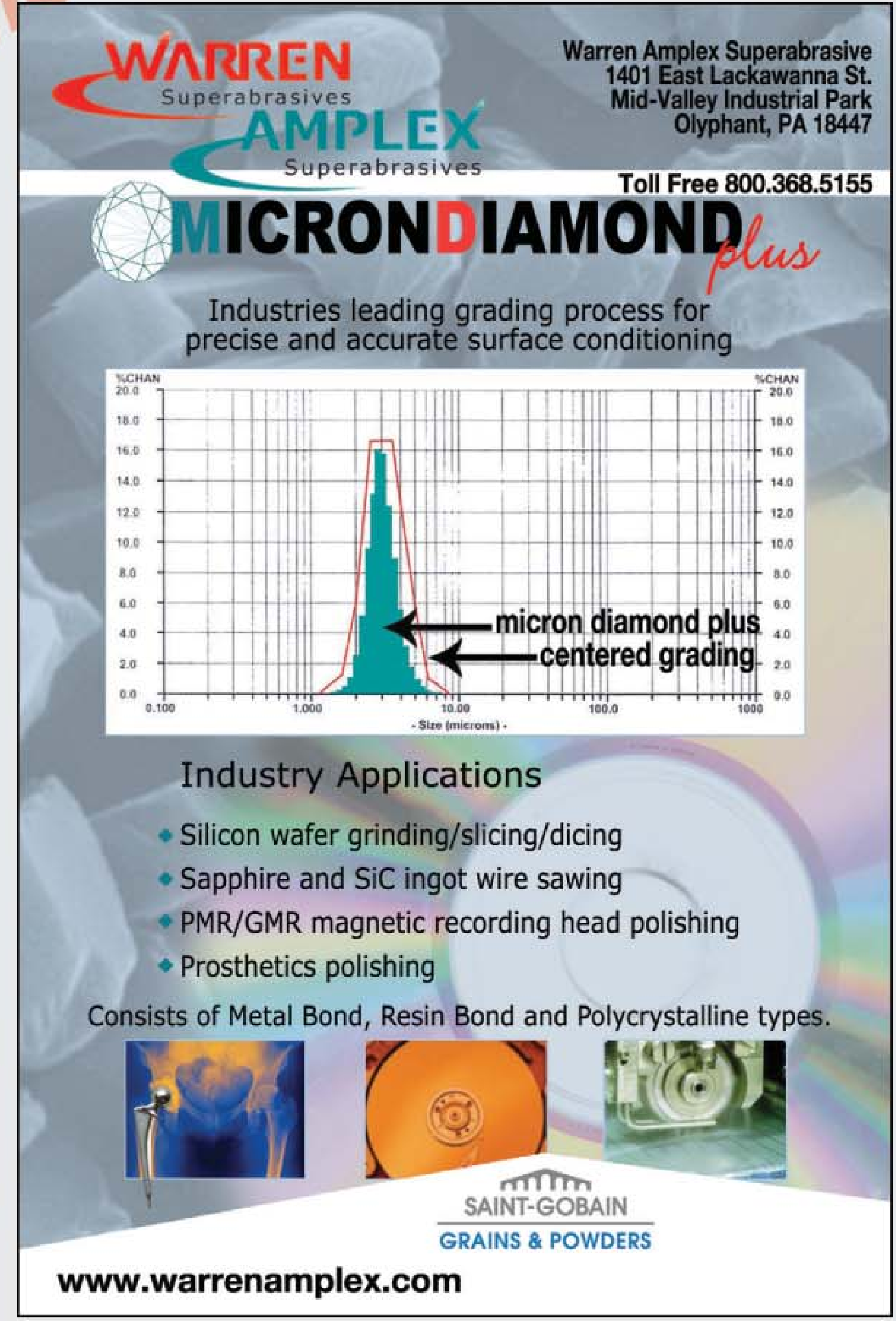
Ultratough Single Crystal Diamonds by MPCVD

Qi Liang, Chih-shiue Yan, Yufei Meng, Joseph Lai, Szczesny Krasnicki, Thomas Yu, Haiyun Shu, Ho-kwang Mao, and Russell J. Hemley - *Geophysical Laboratory, Carnegie Institution of Washington*

ABSTRACT

Recent progress in microwave plasma chemical vapor deposition (MPCVD) has enabled the fabrication of high quality, gem-size single crystal diamonds at very high growth rate that have tunable mechanical properties. Vicker hardness tests were used to evaluate the hardness and fracture toughness of these crystals. It was found that the nominal fracture toughness of CVD diamonds grown under $H_2/CH_4/N_2$ chemistry is around 15 ~ 20 MPa $m^{1/2}$, with respect to 10 ± 2 MPa $m^{1/2}$ of Type Ib diamonds, and 8 ± 4 MPa $m^{1/2}$ of natural Ia and IIa diamonds. Further enhancement in toughness was observed for single crystal diamonds grown after post-growth treatments; the fracture toughness could be improved by at least a factor of two. No radical fracture was observed around Vicker indentation craters, creating difficulty in measuring this very high toughness. Crystals with different color grading from light brown to colorless were synthesized by fine-tuning CVD gas chemistry, growth conditions, and post growth treatments. PL and IR spectra were used to characterize the crystals. These new diamonds could be used in new application in optics, electronics, and mechanical applications. In particular, low cost tough and ultratough CVD single crystal diamonds can play an important role in machining and abrasive industries.

Large scale production of synthetic diamond has long been an objective of both research and industry. Diamond, in addition to its gem properties, is the hardest known material. However, diamond is also known as a brittle material. It has been reported that fracture toughness (Kic) for type Ia diamond is between 7.0 and 8.4 MPa $m^{1/2}$; for type IIa diamond, Kic is 4.2 ~ 5.6 MPa $m^{1/2}$. Improvement in growing single crystal CVD diamond (SC-CVD) by the microwave plasma chemical vapor deposition (MPCVD) process has enabled the fabrication of large size (over 3 ct as commercially available HPHT synthetic Ib diamond), high quality diamonds. Using a gas chemistry of $H_2/CH_4/N_2$ in the MPCVD process, {100} growth was significantly enhanced by varying substrate temperature, pressure, power, and N_2 flow rate. The color of the SC-CVD that can be synthesized range from dark brown and light brown, to near colorless and colorless. In this study, HPHT synthetic type Ib and SC-CVD with {100} surfaces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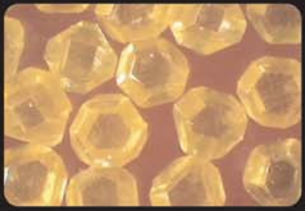

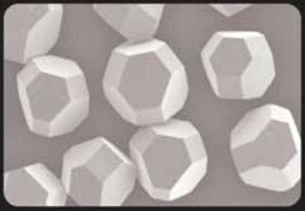

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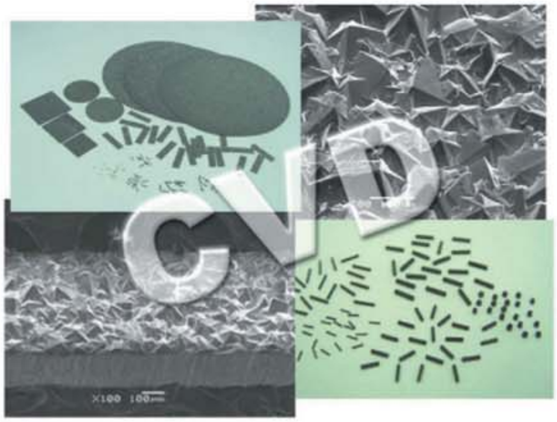

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BOEING

Cutting Tool Material Requirements for the AIRFRAME INDUSTRY

JEFF LANTRIP, Commercial Airplanes • The Boeing Company

CHANGES IN THE AIRFRAME INDUSTRY

In order to increase the efficiency of aircraft and reduce the life cycle costs, there has been an increased use of composites and titanium. The Boeing 787 and the Airbus A350 airframes will be mostly composite, as well as Hawker Beechcraft's Premier IA and Hawker 4000 (all-composite fuselages), and Eviation's EV-20 Vantage (all composite fuselage and wings) in the business jet field. The use of composites facilitates part consolidation and bonding, reducing the number of fasteners. However the majority of fasteners eliminated are those termed "acreage fasteners," large numbers of smaller diameter fasteners that lend themselves to automation. Most of the holes that are left are more difficult holes; larger diameter holes in thicker, multiple material stacks. Since there is a galvanic corrosion issue with contact between graphite composites and aluminum, the structural components attached to graphite composites are generally titanium. These two materials are difficult to drill by themselves, and even more difficult when drilled together in a stack. They have different cutting requirements, not only different drilling parameters, but different requirements for a cutting tool material.

Carbon Fiber Composites Machining Challenges

- Material is very abrasive – results in high wear rates
- Anisotropic properties (due to combination of soft matrix and hard fibers in varying orientations) – thus cutting tool sees varying cutting resistance
- Plastic matrix – limits cutting temperature
- Fiber reinforcement – requires sharp cutting edge, high shear geometry and high velocity to be cut cleanly
- Laminate structure – prone to delamination under excessive cutting forces (e.g., high drilling thrust)

The airframe industry has been undergoing a major change with the increased use of composites in structural applications. This drives the increased use of polycrystalline diamond, CVD diamond coating, and other superhard cutting tool products. However, along with the increased use of composites, there is also an increased use of titanium, and the need to drill holes in stacks containing both materials. This is a very challenging application that requires a cutting tool material that is both very hard and tough. This presentation will outline the requirements for new cutting tool materials for the airframe industry.

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Technique for the measurement of mechanical strength and fracture mechanisms of metal bond micron diamond.

Benjamin R. Rosczyk, Laura M. Nagle and Ion C. Benea, Ph.D., Engis Corporation

Abstract

The abrasive behavior of diamond powders are based primarily on the particle strength and fracture characteristics. Metal bond, micron diamond graded from several feed sources was crushed under compressive and shear forces in a patented, Engis-developed diamond crushing apparatus to determine the relative crushing strength index (CSI). The particle size distributions before and after the crushing tests were used to determine the crushing strength and fracture mechanisms of the micron diamond.

Introduction

Historically, the crushing strength or friability of diamond powders have been measured using a free moving hard metal sphere encapsulated with the test powder inside a metal cylinder. The cylinder is "reciprocated back and forth in the direction of its axis with the result that the ball is thrown from end to end inside the capsule". The free-moving sphere provides impact stress to the diamond powder and several types of equipment have been developed for this technique. The ANSI standard method for friability covers only mesh size diamond and cBN powders. After crushing, a sieve is used to determine the mass of "on-size" particles remaining after a given test time. The relative strength is determined by the test time required to crush 50% of the sample mass. The use of sieves in this technique limits the resolution of this method as well as the size of diamond powders that may be tested. Other investigators have measured the friability index of diamond powders down to 3mm using a shaker mill with laser light scattering to analyze the particle size distribution of the crushed/milled powder [3]. In both of these methods, the primary crushing method is impact force. However, in applications such as lapping, most force is applied through shearing of one surface against the other. In the past, we have tested the Crushing Strength Index (CSI) of micron sized diamond powders using an Engis-developed crushing apparatus by dry-crushing powder between two flat, hard surfaces to more closely approximate lapping conditions. Yet, most lapping uses a lubricant with the abrasive particles which prevents compaction of dry powder. In the present study, diamond powders mixed with a lubricant were crushed with the same Engis-developed crushing apparatus under compressive/shear forces. This thin "wet" layer of abrasive particles most closely simulates lapping conditions of free abrasive particles. The measured particle size distribution before and after crushing can then be used to calculate the CSI.

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Experimental

3.1 Diamond powder characterization 3.1.1 Particle Size Distribution.

The particle size distributions of several commercially sourced monocrystalline micron diamond powders were measured using the electrical sensing zone method (Beckman-Coulter Multisizer 3) using a conductive diluent (Isoton II).

Particle Shape Characterization

Diamond powders were analyzed with a proprietary optical analysis technique to measure the size and aspect ratio of each particle. The aspect ratio is defined as the ratio of the longest and shortest particle radii that pass through the geometric center of the particle. Therefore, a circle would have and aspect ratio of 1 and a thin rod an aspect ratio approaching zero. To more closely examine the small percentage of particles with a more elongated shape, the number % of particles with an aspect ratio less than 0.15 was also calculated.

3.2.2 Crushing Strength Index (CSI) measurement

The crushed and uncrushed diamond powders were diluted with de-ionized water and dispersed by ultrasonic probe (VibraCell model VC501, Sonics and Materials, Inc.) The

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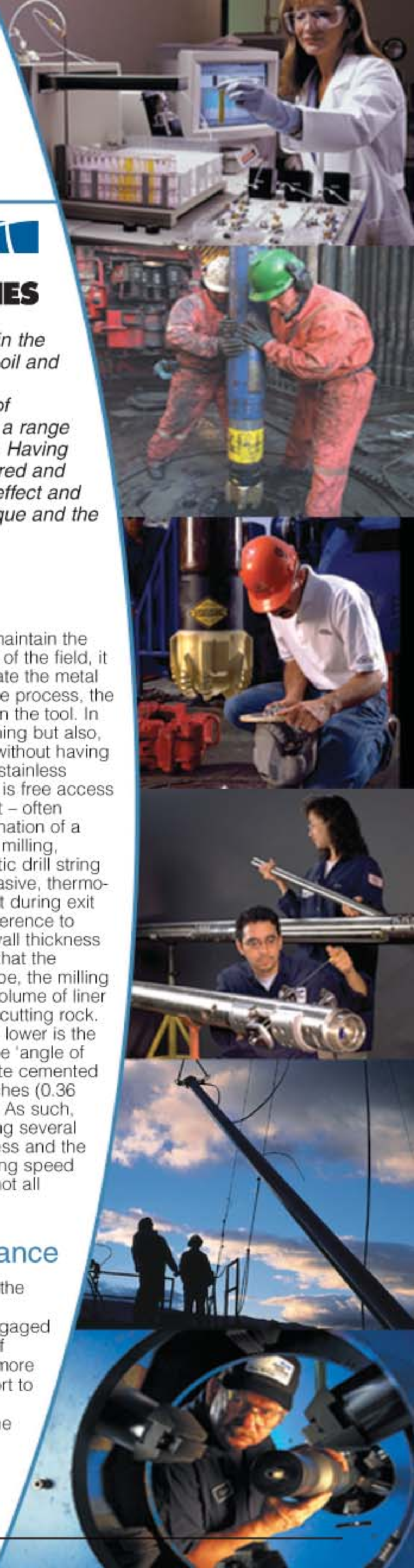
Drilling Oblique Holes in Duplex Steel with PCD Tools

J. Barry, D. Scott (Hughes Christensen)

The production of oil and gas in high cost offshore locations requires the use of duplex stainless steel liner pipes in the well bore. Furthermore, efficient production of certain fields require the drilling of secondary bores which in turn requires the penetration of the steel liner in the main bore, so as to enable further drilling through rock. The high cost of operating oil and gas production facilities calls for efficient drilling of the liner so as to minimise the downtime. Limited torque on bit and non-ideal system dynamics limit the degrees of freedom for process optimisation. The present work first assesses the suitability of a range of cutting tool materials for cutting duplex steel under a range of cutting conditions. Having thus identified PCD as the most appropriate cutting tool material and having captured and modelled the cutting force data – incorporating the compounded influence of size effect and tool wear – a geometric model is developed which predicts the evolution in the torque and the axial and radial forces acting on the bit.



Introduction

Well bores for the production of oil and gas are frequently lined with metal pipes so as to maintain the integrity of the bore and facilitate servicing. In order to access reserves in different regions of the field, it is sometimes necessary to drill secondary bores off the main bore and in doing so, penetrate the metal liner. Milling an 'exit window' in the liner metal is not straightforward as for the majority of the process, the bit must cut both rock and metal and these two materials impose very different demands on the tool. In the search for greater efficiency, it is further desirable not only to penetrate the well bore lining but also, to continue drilling for a significant distance and ideally, realise the entire secondary bore without having to raise the drill string and replace the bit. Of the metals used for lining well bores, duplex stainless steels are perhaps the most difficult to machine. Even in a metal-cutting shop, where there is free access for manual intervention to the process, duplex stainless steels are notoriously difficult to cut – often requiring very narrow operating windows for even the most moderate tool lives. The combination of a sticky, highly work-hardening stainless steel with an abrasive brittle rock, as in exit window milling, presents a highly demanding bi-material machining process. When compounded with erratic drill string and bit dynamics, the cutting tool materials employed in the bit are subject to extreme abrasive, thermo-chemical and toughness demands. In order to appreciate the work load imposed on the bit during exit window milling, it is useful to consider some of the mechanical quantities involved. With reference to Figure 1, a typical liner pipe may have a diameter, D, of 6 inches (152 mm) or less and a wall thickness of _ inch (12.7 mm). The milling bit typically engages the liner pipe at a slight angle, such that the inclination between the axes of both is just a few degrees. In order to fully penetrate the pipe, the milling bit must progress a total linear distance of several tens of feet and in doing so, remove a volume of liner of several hundred cubic inches, whilst – for the majority of the operation – simultaneously cutting rock. It is clear that the larger the degree of misalignment between the bit and the liner pipe, the lower is the volume of material to remove and potentially, the lower the wear on the cutters, however, the 'angle of attack' is limited in practice by the directional-drilling apparatus. Considering an appropriate cemented carbide cutting tool for metal-cutting shops as a reference; a stock removal of 20 cubic inches (0.36 Litres) would be accepted as a reasonable tool life when machining duplex stainless steel. As such, the stock removal in exit window milling can be considered large, even with a bit comprising several tens of cutters and neglecting the wear generated by the rock-cutting element of the process and the dynamic loading due to forced and natural vibrations. It should also be noted that the cutting speed varies across the bit diameter and as such, where an optimum cutting speed might exist, not all cutters can operate under such conditions.

Laboratory Metal-Cutting Tests and Tool Wear Performance

It will be evident from Figure 1 that each cutter on the bit experiences an interrupted cut. In the very first and last stages of the exit window milling process, cutters are engaged for up to (approximately) one third of a revolution, while for the majority of the process, cutters are engaged in the liner for a distance approximately equal to tube wall thickness (or about 20 degrees of rotation). This is considered a key aspect of the process which would be overlooked in the more typical continuous cutting tests employed in metal cutting research. Therefore and in an effort to use the actual duplex stainless steel liner pipe used in the field, an eccentric face-turning arrangement was devised in which the tube is clamped offcentre in the chuck of a CNC lathe and the tool fed across the face with a constant cutting speed, depth of cut and feed.

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HIGH PRESSURE CMP with Low Stress Polishing

Author: Hiroshi Ishizuka, Tomei Die International Co., Ltd.
Presented by: Barnas Monteith, Advanced Diamond Solutions

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ABSTRACT

Low stress polishing is required for the manufacture of advanced integrated circuits (IC) with node sizes of 45 nm and smaller. However, the CMP community achieved the low stress by reducing the down force that press the wafer against a rotating pad. The reduced down force also decrease the removal rate of the wafer. As a result, the productivity suffers. In order to cope with this problem, an electrical potential is applied to the copper layer during polishing, in this case, the chemical oxidation is accelearated and hence the romoval rate. Alternatively, the rotating pad must be softened to minimize the defects of wafers caused by CMP. In this research, we report a simpler solution to achieve low stress polishing without investing in new equipment and in developing new pad materials. The conventional CMP is proceeded by dressing the pad with a PCD dresser that can form 10X more asperities on the pad surface. The fluffy surface can then polish delicate IC without using the brutal force. As a result, the removal rate of wafers can be maintained without causing defectivity on the IC layer.

LOW STRESS POLISHING

Due to the relentless progression of Moore's Law, the IC nodes are being down-sized to 45 nm toward the end of 2007, and will be in production of 32 and 22 nm in the next few years. The virus sized copper circuitry requires ultra low k dielectric insulator to minimize the RC delays between interfering currents. As the shear strength of the insulator is inversely proportional its dielectric constant, the contact pressure during CMP must be reduced by about one order of magnitude.

LOW STRESS POLISHING

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Fig. 1: The strength of insulator is greatly reduced by increasing the amount of porosity as the requirement to minimize dielectric constant. In order to cope with the delicate dielectric layer, the CMP industry is coming with two distinct strategies. Applied Materials as the dominant polisher maker is advancing eCMP technology with electrical oxidation of copper upon the contact with the high points of pad asperities. The ooze of oxide can be wiped clean with the minimal stress. eCMP has been tested at TSMC, IBM, Micron, AMD and others. Fig. 2: The appearance of eCMP equipment (top diagram) and the boost of polishing rate by applying an electrical potential (bottom diagram). On the other hand, Rohm-Haas, the major pad supplier, is introducing a new pad (Eco4000) with a much larger compressibility of the pad surface compared to conventional IC pads that has been the industrial standard for CMP. The pad can allow an order of magnitude higher contact area between wafer and pad during polishing without unduly concentration of stress that may damage the delicate IC. Fig. 3: The contact area between wafer and pad may be increased by softening the pad material or by densify the surface asperities. The above two distinct approaches toward reducing the contact stress have their limitations. On one hand, the implementation of eCMP requires new equipment, new conductive pad, new pad conditioner, and new process, so the entry barrier is insurmountable. Although the modification of the pad properties

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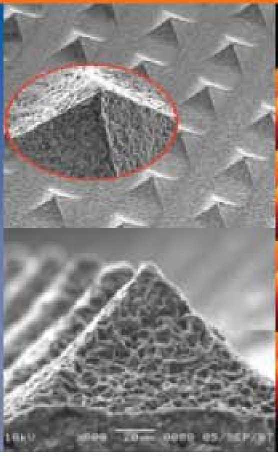

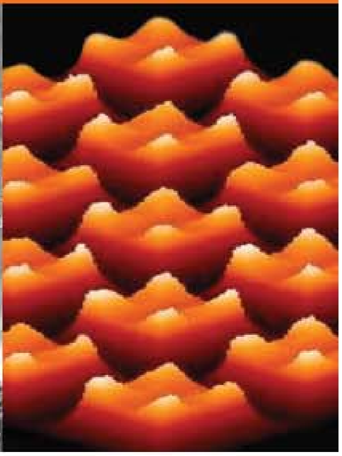

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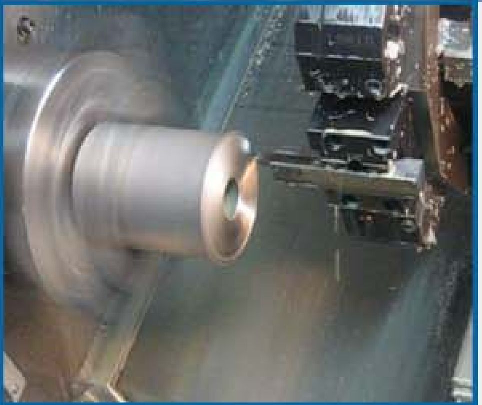
A New Low Cost Accelerated PCD Abrasion Test Method

D. Slutz, R. Clark, Morgan Carbon

This work has demonstrated that an accelerated test can be performed using tungsten carbide as the workpiece material. The ranking of PCD materials was verified by testing the same PCD materials with a conventional work-piece material (Table 12). This method has the advantage of allowing abrasion tests to be performed in less time and at a lower material cost than the conventional methods.



ABSTRACT

An accelerated PCD abrasion test has been developed using cemented tungsten carbide as the abrasive work-piece. With appropriate machining parameters, the cemented tungsten carbide is in excess of 1000 times more abrasive than conventional materials such as aluminium alloys A390, A394 and Duralcan traditionally used for this abrasion test. This accelerated test significantly reduces the amount of machine time required to perform the test and the volume of work-piece needed. The end result is an abrasion test that can more quickly and cost-effectively distinguish product differences than can currently be achieved utilizing aluminium alloy work-pieces.

INTRODUCTION

The typical abrasion test for cutting tool products involves measurement of the flank wear of a single point cutting tool as a ratio of the volume of work piece removed under constant cutting conditions. The preferred work-piece materials used for such a test are A390 aluminium, A394 aluminium, and Duralcan. These materials are chosen for their high silicon or silicon carbide (>17%) content. The high silicon or silicon carbide content is responsible for the abrasiveness of these materials. A highly abrasive work-piece is desirable in order to reduce the required volume of work-piece removed before end of life flank wear has occurred on the PCD cutter edge. This also reduces the time equired to wear a PCD tool to this end-point. Reducing the volume of the work-piece required and the time to perform the test reduces the overall cost of performing the test.

EXPERIMENTAL

The abrasion test is usually performed by one of the following two methods.

a) Turning the OD

A typical single point cutting tool is manufactured in the configuration shown in Table #1. The single point cutting tool is used to machine the outer diameter of a work-piece for a set length along its outer diameter. Typical conditions used are shown in Table #2. Measurements of the work-piece and the PCD flank wear are made at defined times or after a defined number of passes. The test is considered complete when the flank wear equals or exceeds 0.015". One advantage of this method is the constant spindle speed used for each pass. The spindle speed needs to be increased on each successive pass in order to maintain a constant surface speed and this can be done on a simple lathe, without CNC capability. One disadvantage of this method is that for each successive pass, the volume of work-piece removed decreases, reducing data linearity. In addition, the maximum spindle speed for the machine will limit the final diameter of the work-piece that will maintain the desired surface speed. Another disadvantage of this test method is that each pass may not be cutting the same abrasiveness of material. Work-piece materials such as cast aluminium alloys may have variations in the material properties, including abrasiveness, from outer diameter to inner diameter. The effect of this can be somewhat mitigated by ensuring each tool cuts from maximum diameter to minimum diameter for each test.

b) Face off Surface of Cylindrical Tube

The second method is to face off the front surface of a cylindrical tube. This method has the advantage that for every pass, the same volume of work-piece is removed. In addition, the test removes a complete sample of material from inner diameter to outer diameter, so if there are any radial variations in the material each pass gets a consistent representative sample of the work-piece. In order to maintain constant surface speed, the spindle speed needs to increase as the cut progresses from outer diameter to inner diameter. Consequently, this test does require a CNC lathe. The same single point cutter configuration and machine parameters can be used as shown in Table #1 and Table #2 respectively.

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Developments in high production peel grinding in water based coolants.

BEN CORNBOWER – WELDON SOLUTIONS, YORK PA
MIKE HITCHINER – SAINT-GOBAIN ABRASIVES, ROMULUS, MI

Peel grinding is a well-recognized process for achieving flexible, high precision profile grinding of small batch production. The process is a highly energy efficient, high speed, low force grinding method pioneered in Europe using oil based coolants to achieve economic abrasive costs. The environmental demands for water based coolant in the USA market has driven innovation in machine, process and wheel bond technology to provide effective solutions in this coolant type. Examples are given from the aerospace, automotive and pump industries where economic small batch production is achieved with cycle times up to 3X faster than traditional plunge grind processing.

INTRODUCTION

Peel grinding is one of the most efficient method of grinding incorporating many of the benefits of high wheel speed and high specific metal removal indentified and developed over the last 25 years. To understand these benefits one must start with the basics of the grinding interface. Interactions at the interface can broadly be considered to be divided into those of actual cutting or chip formation, plowing or workpiece deformation, and various sliding or frictional loss processes. All these processes dissipate energy, and at metal removal rates typical of traditional finish or precision grinding, the unproductive processes of plowing and sliding can consume the majority of the grinding power. Furthermore, chip formation in cutting is an extremely high strain extrusion process and very sensitive to chip size. Specific energy for fine grinding with a stock removal rate of Q' = 0.1mm3/mm/sec can easily exceed 100J/mm3 while even at traditional precision grinding removal rates of e.g. Q = 5 mm3/mm/sec the specific grinding energy can be 30 – 50 J/mm 3 where up to 75% can be dissipated in plowing and sliding. If stock removal rates can be increased to the order of Q' = 100, the energy required for ploughing and sliding remains almost constant such that their significance in the total energy required becomes negligible and specific grinding energy can fall to as low as 10J/mm3 grinding steel. The significance here is two-fold; first if the specific energy drops from 50J/mm3 to 10J/mm3 then for a given wheel spindle power it is possible to remove up to 5X more workpiece material; second since the grinding force is the power divided by the wheel speed, for a given spindle power and wheel speed it is possible to remove 5X the material for a comparable level of force on the workpiece and thus a comparable system stiffness. The problems to be overcome to exploit this opportunity are then twofold, namely how to avoid the need for very large wheel spindle power, and how to achieve a cost-effective wheel life. A solution involves focusing the high stock removal into a very small area combined with the use of high wheel speed, and the use of highly durable grinding wheel abrasives and bond systems. In the past it has also required the use of oil coolant but, as this paper will describe, recent developments have relaxed this need.

The geometry of a standard peel grinding process (also called contour profile grinding) is shown in Figure 2. The wheel is narrow, barely 5mm, and grinding occurs over the leading 30 – 50% of the width. For a nominal stock removal depth of z/2, the actual depth of cut ae is calculated from the length of the cutting land angled at tan-1 [(z/2)/("Stock removal")]- typically 5°, and the traverse rate. This angle may be dressed in the wheel face or often will simply break in rapidly then stabilize depending on the wear characteristics of the wheel. It may also adjust shape based on the traverse rate of the wheel across the workpiece and as wear proceeds. The trailing 2 – 3 mm of the wheel face generates the required finish and maintains the final part size.

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New Coating of Ti-Based Alloy on Diamond Grains for Iron Bond Matrix

Bo-kyung Ahn
Sirk-ihl Lee
Hong-jin Choi
ILJIN Diamond Co., Ltd.

Abstract

A study is performed on the metal coating of diamond grains, which is applied to protect diamond surface at elevated sintering temperature. This metal coating, T2, is based on Ti and contains several other elements such as Cr, Al. T2 coating is designed to protect diamond surface under highly reactive conditions at elevated temperature so that diamond would maintain its strength in a bond system with high content of iron. Segments are made with Fe based bond. The test result shows that T2 coating is better than T1 coating in protecting the diamond surface with improved wear and corrosion resistance.

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Introduction

Diamond is the hardest material in the world, so it is manufactured as a tool for cutting, grinding, polishing. But, one of weakest problem of diamond applying for a tool is re-graphitization phenomenon. When a diamond tool cuts workpiece, very high heat occurs by attrition. By the way, when a diamond is exposed to the air, it cannot perform properly because re-graphitization can happen near 850°. Another problem is originated from bond materials. A diamond is consisted of covalent bond, but bond material used by metal powders having metallic bond. So there is poor adhesion between diamond-metal interfaces. In order to manufacture a tool, diamond and metal powders must be mixed homogeneously then sintered at high temperature. But the problem is the retention force between diamond and metal powder is very weak. To overcome these problems, coating is one of the most appropriate methods. If metal elements that were able to form carbide with diamond were coated, carbide is formed at coating layer-diamond interface. This carbide is able to make retention force be much stronger than uncoated diamond. Also tools manufactured with coated diamond have better performance compared with uncoated diamond. Because the surface of coated diamonds was consisted of metallic bonds like bond matrix, the retention force was increased. Coated diamond has higher oxidation resistance than uncoated diamond because the coating layer acts as protective layer. Lastly, the price of raw materials is extremely unstable and cobalt commonly used as a bond material is placed in same condition. Iron is substitutive material for cobalt because it has much lower price than cobalt. But iron is very harmful substance for diamond, so new coating composition is essential. In this study, newly developed coated diamond will be introduced for iron bond matrix. From the experimental results, it protects the diamond effectively and increases the oxidation resistance. Also the tool life of the tools

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Case Studies in Carbide Grinding

S. Kompella§, J.H. Fiecoat, G. Ruland, and C. Downie – Diamond Innovations

ABSTRACT

Tungsten carbide tool and cutter grinding is generally conducted with nickelcoated diamond abrasive held in a resin matrix. The grinding process economics is influenced by wheel life and specific energy which, in turn, determines part quality. In this paper, we examine the various components in a carbide grinding process – the wheel-work geometry, workpiece composition, and wheel composition. The role of grinding contact geometry on wheel performance, at a constant material removal rate, is evaluated. Further, the influence of workpiece compositional variation on tungsten carbide grindability is assessed. Finally, in a coating design study, the effect of nickel coating type on grinding wheel life is monitored. It is shown that the nature of the coating has a significant bearing on wheel life and grinding performance. Furthermore, based on grinding results with commercially available coated diamond crystals, the importance of appropriate coated abrasive choice in the context of the grinding parameters is discussed. It is shown that abrasives with apparently comparable visual attributes show a significant variation in grinding performance and, hence the grinding system cost.

INTRODUCTION

Cemented tungsten carbide ("hardmetal") is widely used in the cutting tool industry in the form of inserts, end mills, drills and related tools. It is also prominently employed in forming applications, for example in fabrication of dies and rolls for paper mills. The hardness of tungsten carbide (WC) particles coupled with the cobalt content in cemented carbides provides it the desired hardness and fracture toughness for many applications. Cobalt is generally in the range of 6-15% for tungsten carbide as used in metal cutting applications. Higher cobalt content may be used in metal forming applications like in dies, rolling mills, and wear parts. Grindability of various grades of carbide have been studied; a correlation between the carbide grain size and grinding performance has been reported. Finish grinding of cutting tool inserts and fluting applications in round tools most often use nickel-coated diamond abrasives in grinding wheel bond systems consisting of phenolic or polyimide resins, or resin-metal hybrids. Grinding costs are determined by how quickly an operation can be accomplished, how long a grinding wheel lasts, and the rate of scrap and/or re-work generated in the process. Choosing the appropriate coated diamond abrasive and grinding parameters are important to ensuring high productivity.

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Fall 2008	Machine Tools & IMTS Preview	July 31, 2008
Winter 2008/2009	Polycrystalline cBN & Diamond	Nov. 30, 2008
Spring 2009	Superabrasives Resource Directory	Mar. 31, 2009
Summer 2009	New Superabrasive Applications & Products	May 31, 2009
Winter 2009/2010	INTERTECH 2010 Preview	Nov. 30, 2009

***Editorial topics subject to change**

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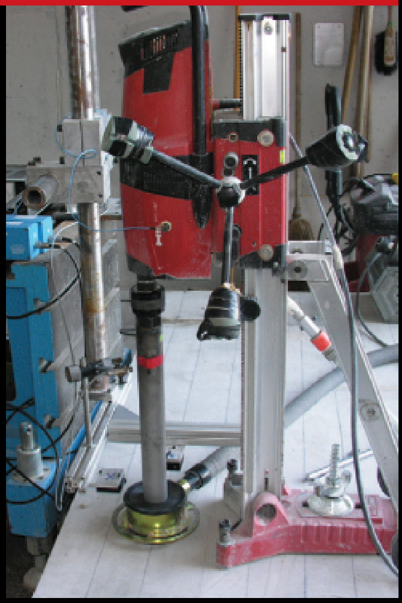

Core Drilling in Reinforced Concrete Using Polycrystalline Diamond (PCD) Cutters: Performance Modelling

ABSTRACT

A summary of the PCD wear and fracture mechanisms observed in the rotary core drilling in reinforced concrete has been published elsewhere [1], but in addition to simply quantifying these mechanisms, the wear evolution and its influence on drilling parameters were also measured. These measurements provided important input parameters into a semi-empirical physical drilling model based on indentation theory. The basis of the model along with a comparison between drilling performance predictions and actual drilling test results are presented in this paper. The drilling model for diamond impregnated segments on which this PCD model is based has previously been described [2]. The experimental development of the optimum core bit design (cutter geometry and number of cutters) to match the available drive parameters (torque and rotational frequency, RPM) was therefore complemented by modelling. This was the first phase towards a full system development of tool, accessories and core bits for dry drilling in reinforced concrete.

DRILLING MODEL

Brief Description of the Model

The semi-empirical model is based on wedge indentation theory, and is essentially a modified "reversed hardness model", predicting cutter indentation depth and calculating penetration per revolution in a concrete of known "hardness" and "drillability". This is then transferred into drilling speed values. Three different end-of-life criteria are considered, based on wear and fracture. The influence of wear (cutter blunting) on drilling speed is taken into consideration by the models' continuous adjustment of the primary input parameters in 1m drilling depth increments. This differs from the related model for diamond impregnated segments [2], where ideal and steady-state conditions are assumed. A number of input parameters are necessary to achieve useful output from such a model. Many parameters can be measured directly, while others must be determined in the validation and calibration stages of modelling, by comparing model outputs with actual values and adapting the input values to achieve closer correlation if necessary. Some of these inputs are given in Table 1. The disadvantage of this type of modelling (geometrical-mechanical) versus energetic modelling is that the geometrical

INTRODUCTION

Although PCD has been successfully used for both rock drilling and metal cutting for many years, up to now it has not been commercially applied for the simultaneous cutting of both mineralic and metallic materials, which is the case with reinforced concrete. Hilti already uniquely offers system solutions for dry core drilling with PCD for specialised applications, for example in the dismantling of decommissioned nuclear facilities and drilling in water-sensitive environments such as hospitals, computer server rooms, etc. The first application in particular is extremely challenging, such as shown in Figure 1. PCD cutters are energetically much more efficient and more universal (regarding the material being cut) than diamond impregnated segments, as shown in Figure 2, and therefore provide measurable customer benefits. However, the widespread penetration of this technology into mainstream building and construction markets is dependent on reducing specific drilling costs per unit depth, which can only be achieved when the excellent drilling performance is matched by guaranteed reliability and higher lifetime (drillable depth). Ever since the first products were available to specialized decommissioning and dismantling (D&D) sub-contractors in 2004, only standard tools (also known as "drives" or "motors") have been available and core bit designs have been adjusted to optimise performance under the available drilling parameters (torque and RPM). However, future developments will concentrate on the entire drilling system, with the cutter, bit, tool, rig, hole starting aid and air flushing system under investigation. The drilling model addresses the issue of cutter, bit and drive parameters and can be used in a predictive manner as well as having a descriptive character. Bit speed and lifetime in concrete can be fairly reliably predicted within the boundary limits of the model, although it has not been extended to the case of the rebar (reinforcement steel).

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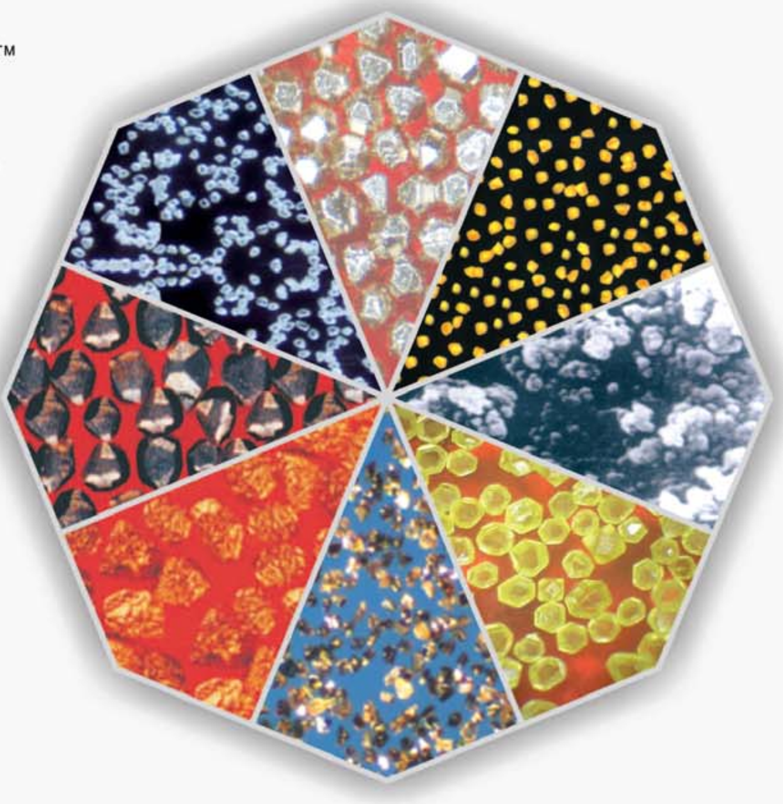

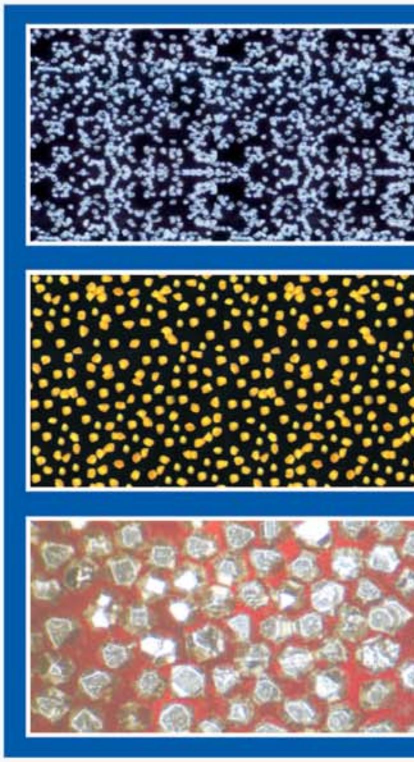

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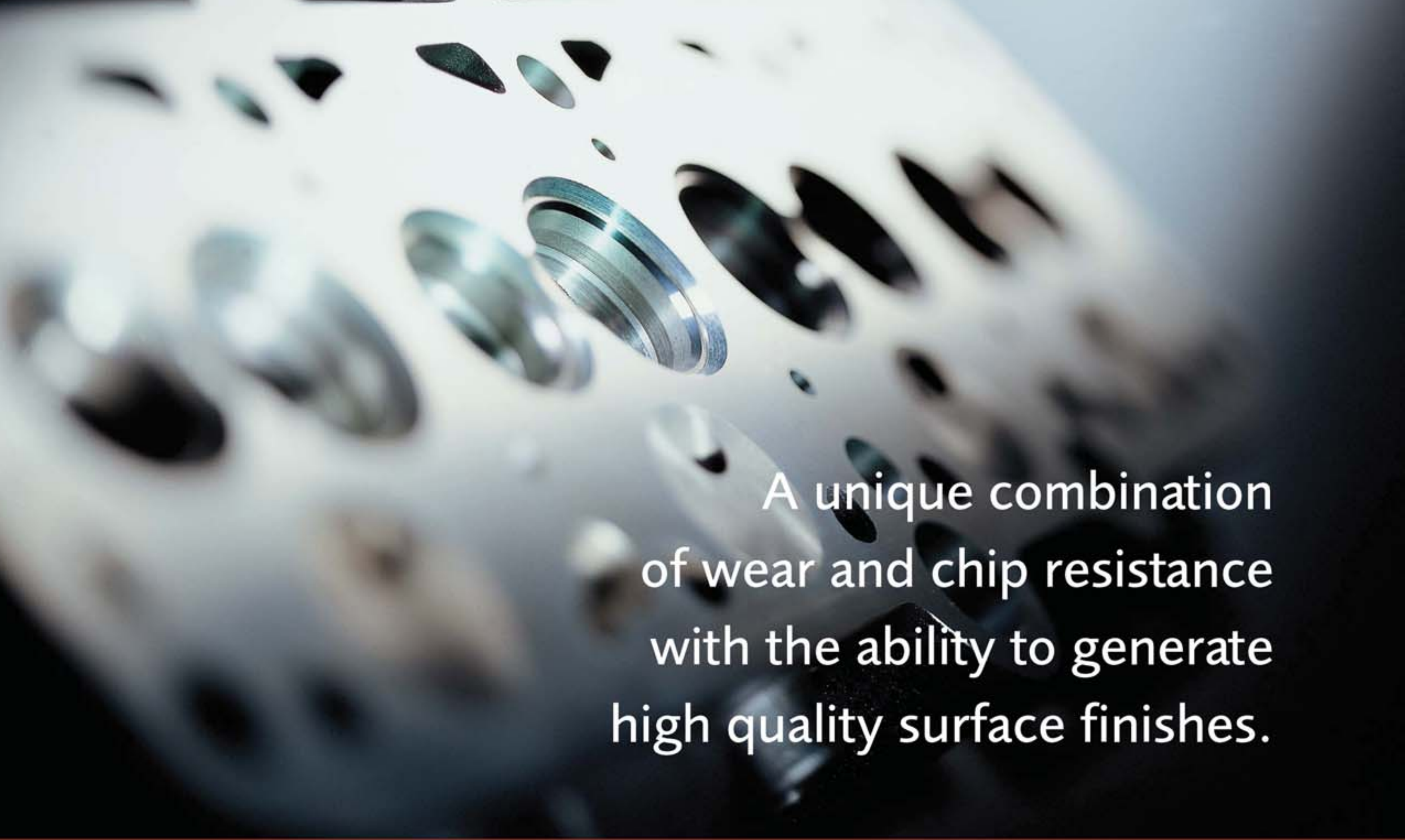
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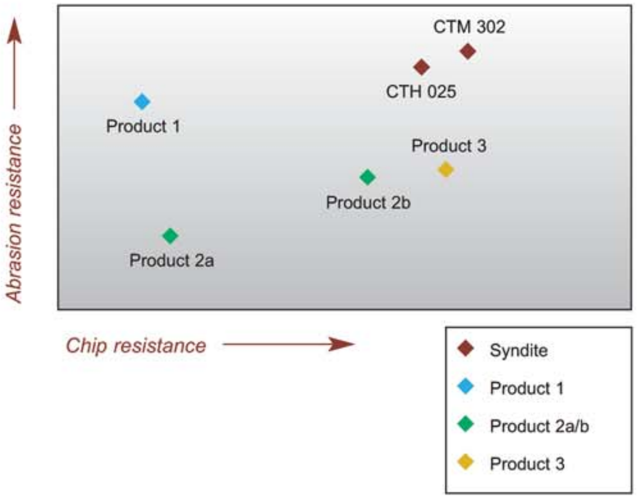
CTM 302 is ideal for the machining of non ferrous metals, like silicon-aluminum alloys and metal matrix composites.

ABRASION RESISTANCE vs CHIP RESISTANCE



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